

# Validation of components of local ties

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Kirchberg, October 13, 2014

# Outline

## 1 Introduction

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- 1 Introduction
- 2 Single-technique solutions
  - Input data
  - Preliminary analysis
  - Results

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  - Strategy
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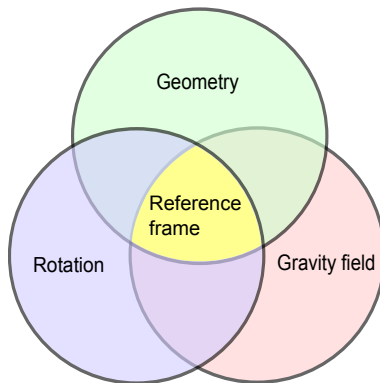
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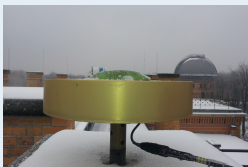
# Reference frame as the realization of a reference system



**Figure:** Reference frame as the connections of the three pillars of geodesy, according to IAG (2014)

# Combination of different geodetic space techniques

## GPS



## DORIS



## SLR



## VLBI





# Combination strategy

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- Pole coordinates as global ties (Seitz et al., 2012)

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- Local ties at co-located sites
  - Inhomogeneous data base
  - IERS Working Group on Site Survey and Co-location
- Pole coordinates as global ties (Seitz et al., 2012)
- Our approach: combination of the pole coordinates and the degree-1 surface load coefficients (Blewitt, 2003), common origin of GNSS and SLR

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# Data

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## GNSS



- daily normal equation systems 1994 - 2010
- GPS and GLONASS
- 334 stations



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## SLR



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## GPS, GLONASS and SLR

from a homogeneous reprocessing (Fritsche et al., 2014)

# Station network

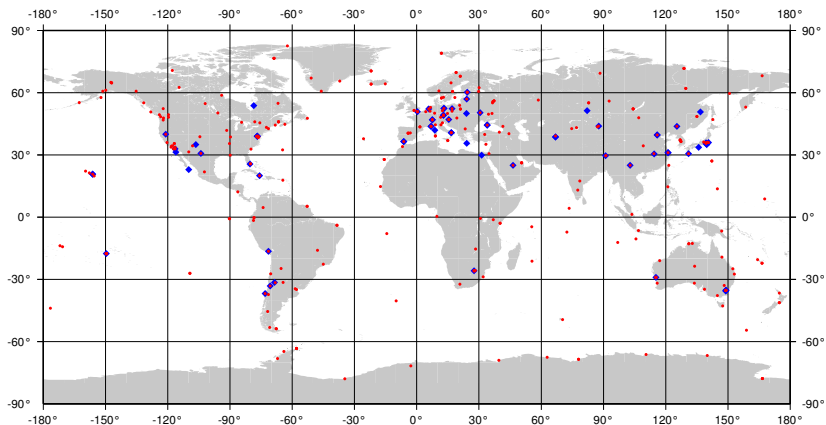


Figure: Globally distributed GNSS (red) and SLR (blue) stations

## Preliminary analysis at station positions time series of all stations

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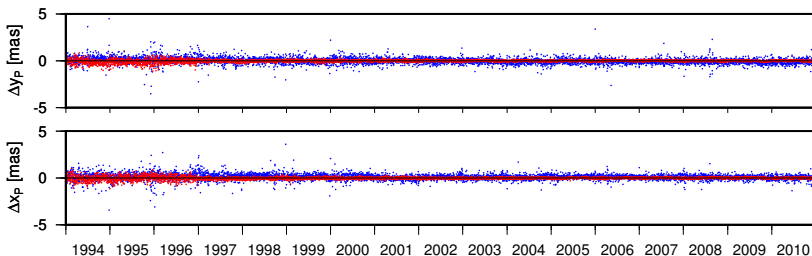
- Elimination of position outliers
- Station events (jumps)
- Core stations for the definition of the geodetic datum

## Preliminary analysis at station positions time series of all stations

- Elimination of position outliers
- Station events (jumps)
- Core stations for the definition of the geodetic datum
  - Selection according to the length and accuracy of the station position time series and the global distribution
  - Similar to IGS and ILRS solutions

# Pole coordinates

# Pole coordinates



**Figure:** Differences  $\Delta x_P$ ,  $\Delta y_P$  of estimated and “IERS 08 C04” pole coordinates

Offset, Trend	GNSS-only		SLR-only	
$\Delta x_P$	-0.04 mas	0.00 mas/a	0.14 mas	0.00 mas/a
$\Delta y_P$	-0.06 mas	0.00 mas/a	0.11 mas	0.00 mas/a



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$$w_{GNSS} = 1$$

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based on Thaller (2008)

# Definition of the geodetic datum

## Combination strategy

- Combination of the pole coordinates of GNSS and SLR
- Combination of the degree-1 surface load coefficients
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- Origin: GNSS and SLR observations
- Network scale: GNSS and SLR observations
- Orientation:
  - NNR around the  $X$ ,  $Y$ ,  $Z$  axis for GNSS
  - NNR around the  $Z$  axis for SLR

temporal change: NNR around the  $X$ ,  $Y$ ,  $Z$  axis for GNSS

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→ minimum constraint solution

# Estimation of components of the local ties

# Estimation of components of the local ties

## Strategy

- a priori positions and velocities
  - $\Delta \mathbf{x}^{LT} = \mathbf{x}_{SLR}^{LT} - \mathbf{x}_{GNSS}^{LT}$
  - same velocities for the LT stations

# Estimation of components of the local ties

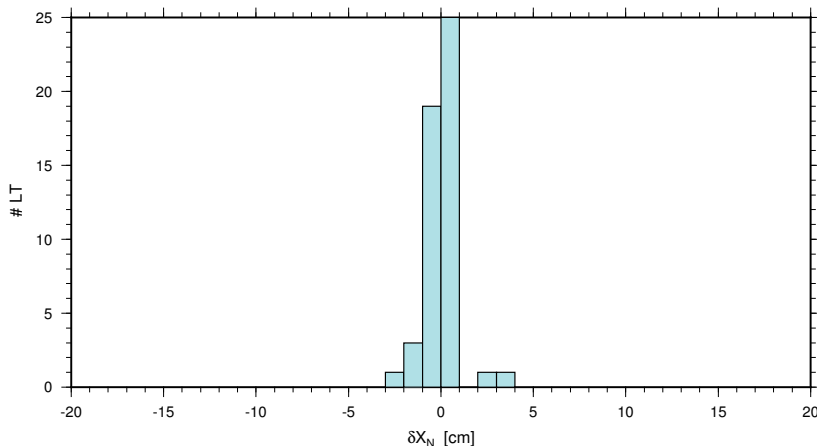
## Strategy

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## Result

$$\delta \mathbf{X} = (\mathbf{X}_{SLR}^{est} - \mathbf{X}_{GNSS}^{est}) - \Delta \mathbf{X}^{LT}$$

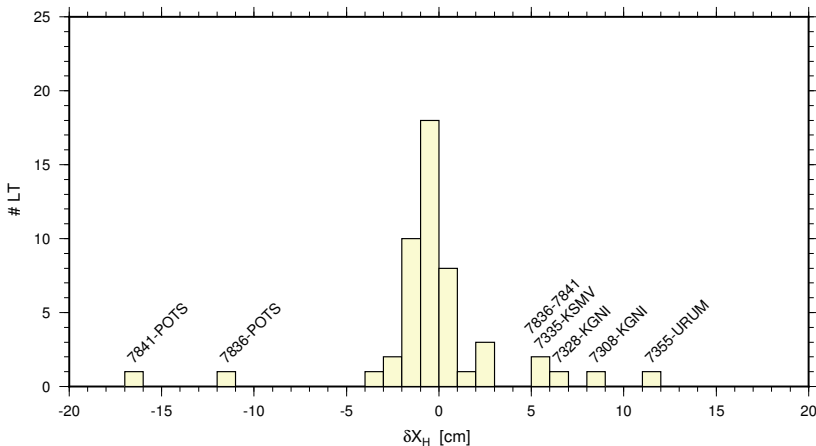
# Local Ties



**Figure:** Histogram of differences  $\delta X_N$  [cm] in the north component of estimated and measured local ties.



# Local Ties



**Figure:** Histogram of differences  $\delta X_H$  [cm] in the height component of estimated and measured local ties.

# Effect of the measured local ties

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## Using a 14-parameter Helmert transformation

- between the single-technique solutions
  - GNSS:  $\mathbf{X}_{GNSS}^{est}$
  - SLR + LT:  $\mathbf{X}_{SLR}^{est} + \Delta\mathbf{X}^{LT}$

## Transformation parameters of a 14-parameter Helmert transformation

GNSS		SLR + LT	
$T_X$ [mm]	$\dot{T}_X$ [mm/a]	1,76	-0,38
$T_Y$ [mm]	$\dot{T}_Y$ [mm/a]	-16,51	0,39
$T_Z$ [mm]	$\dot{T}_Z$ [mm/a]	3,20	-0,14
$R_X$ [masec]	$\dot{R}_X$ [masec/a]	0,031	-0,012
$R_Y$ [masec]	$\dot{R}_Y$ [masec/a]	0,382	-0,007
$R_Z$ [masec]	$\dot{R}_Z$ [masec/a]	-0,147	0,005
$m$ [mm/km]	$\dot{m}$ [mm/km/a]	-0,00064	-0,00025

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- **Estimation** of components of the **local ties** at co-located sites **using** the pole coordinates as **global ties**.
- **Differences** between estimated and measured local ties: 88% in north, 52% in height component below 1 cm.

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- **Estimation** of components of the **local ties** at co-located sites **using** the pole coordinates as **global ties**.
- **Differences** between estimated and measured local ties: 88% in north, 52% in height component below 1 cm.
- **Translation** in direction of  $Y$  and **rotation** of the network around  $Y$  by using all measured local ties.

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- **Combination** of GNSS and SLR with **minimum constraint** conditions.
- **Estimation** of components of the **local ties** at co-located sites **using** the pole coordinates as **global ties**.
- **Differences** between estimated and measured local ties: 88% in north, 52% in height component below 1 cm.
- **Translation** in direction of  $Y$  and **rotation** of the network around  $Y$  by using all measured local ties.

→ Combination of different geodetic space techniques to realize a global terrestrial reference system in the framework of GGOS.

Thank you very much for your attention.

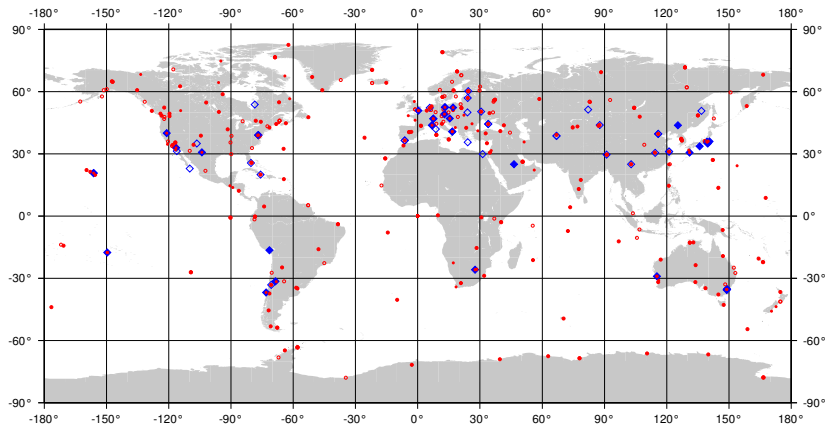
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# References

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# Definition of core stations



**Figure:** Definition of core stations (filled symbol) of the GNSS (red) the SLR (blue) network

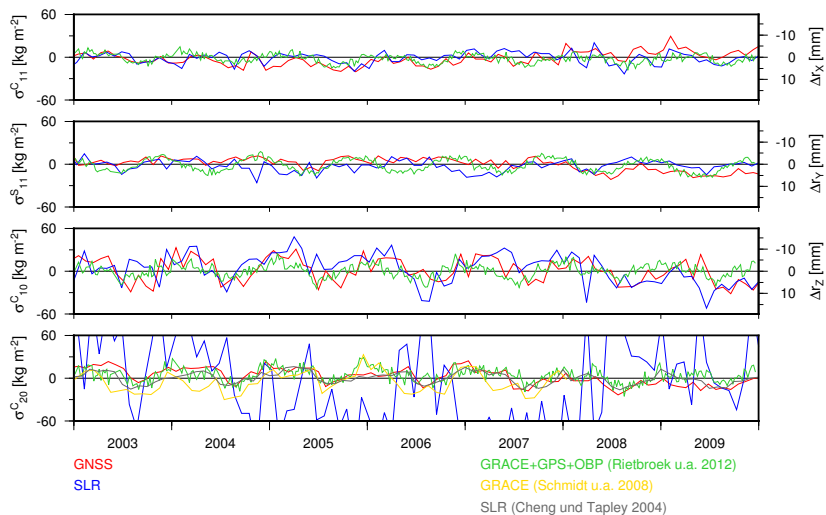
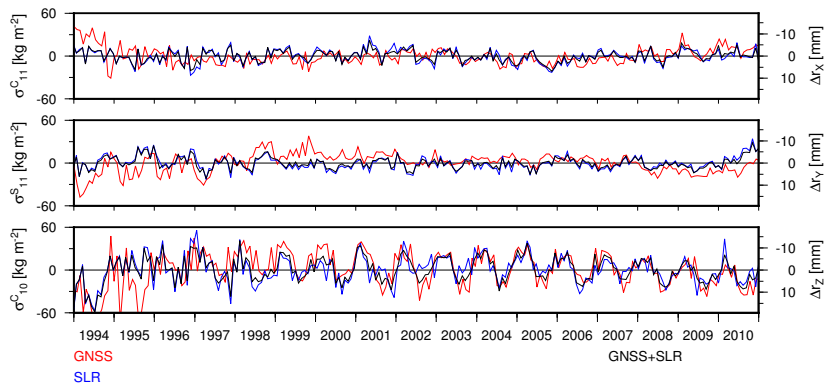


Figure: Surface load coefficients and difference of CF w. r. t. CM

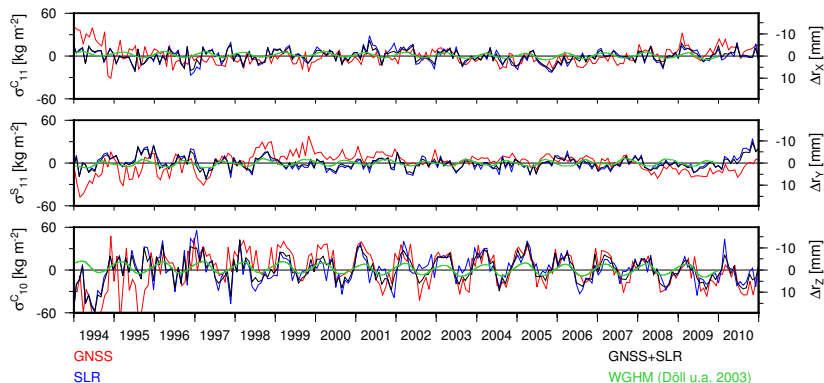
# Modeling of surface loads (Blewitt, 2003)



**Figure:** Degree-1 surface load coefficients ( $\sigma^C_{10}, \sigma^C_{11}, \sigma^S_{11}$ ) (left) and differences  $[\Delta \mathbf{r}_{\text{CF}}]_{\text{CM}}$  (right)



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**Figure:** Degree-1 surface load coefficients ( $\sigma^C_{10}, \sigma^C_{11}, \sigma^S_{11}$ ) (left) and differences  $[\Delta \mathbf{r}_{\text{CF}}]_{\text{CM}}$  (right)